The UZC-SSRS2 Group Catalog

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ABSTRACT

We apply a friends-of-friends algorithm to the combined UZC and SSRS2 redshift surveys to construct a catalog of 1168 groups of galaxies; 411 of these groups have 5 or more members within the redshift survey. The group catalog covers 4.69 steradians and all groups exceed the number density contrast threshold, $\delta\rho/\rho = 80$. We demonstrate that the groups catalog is homogeneous across the two underlying redshift surveys; the catalog of groups and their members thus provides a basis for other statistical studies of the large-scale distribution of groups and their physical properties. The median physical properties of the groups are similar to those for groups derived from independent surveys including the ESO Key Programme and the Las Campanas Redshift Survey. We include tables of groups and their members.

Subject headings: galaxies:clusters — galaxies: distances and redshifts — catalogs

1. Introduction

Catalogs of loose groups have long been a fundamental resource for the study of these abundant systems. Early catalogs constructed with a variety of selection criteria were based on positions of galaxies on the sky (de Vaucouleurs 1974; Turner & Gott 1976; Materne 1978). There has been a steady evolution toward groups selected from redshift surveys of the local universe (Huchra & Geller 1982; Vennik 1984; Nolthenius & White 1987; Tully 1987; Maia et al. 1989; Ramella et al. 1989; Gourgoulhon et al. 1992; Garcia 1993; Ramella et al. 1997; Trasarti-Battistoni 1998; Ramella et al. 1999; Giuricin et al. 2000; Tucker et al. 2000; Carlberg et al. 2001), with the notable exception of White et al.

(1999) who use the Turner & Gott (1976) algorithm to select groups projected on the sky starting from the CGCG (Zwicky et al. 1961—1968).

Here we discuss the group catalogs for the UZC (Falco et al. 1999) and SSRS2 (da Costa et al. 1998) redshift surveys which cover 4.69 steradians of the sky to a limiting $m_{B(0)} \simeq 15.5$. To identify the groups we apply a standard friends-of-friends algorithm (Huchra & Geller 1982). Analyses based on preliminary versions of this catalog are already in the literature. Girardi et al. (2000) and Padilla et al. (2001) compute the group correlation function. Trasarti-Battistoni et al. (1997) identify groups in the Perseus-Pisces region and computes the group correlation function (Trasarti-Battistoni 1998). Mahdavi et al. (2000) cross-correlate a portion of the catalog with the Rosat All-Sky Survey to identify systems which have associated extended x-ray emission. Frederic (1995a,b) and Diaferio et al. (1999) compare the properties of these systems with the predictions of n-body simulations. Issues including spectroscopic and morphological types of galaxies in nearby groups remain to be investigated.

There is wide variation in the group selection algorithms. This variation affects the fraction of galaxies assigned to groups. It also affects the derived physical parameters (Pisani et al. 1992). Frederic (1995a,b) discussed the sensitivity of group identification to the algorithm. A similar discussion is beyond the scope of this paper: all of the redshift survey data are publicly available for examination of these issues.

Here we provide lists of groups and group members to enable reproduction and extension of published results along with comparisons to other group catalogs. We include cross-references to our previous catalogs constructed from partial versions of the UZC and SSRS2. We refer to the entire group catalog discussed in this paper as the *UZC-SSRS2 Group Catalog* which we abbreviate as USGC. Section 2 reviews the redshift surveys and compares the UZC with the SSRS2 in the region of overlap. Section 3 describes the group

selection algorithm. Section 4 discusses the homogeneity of the group catalog across the two underlying redshift surveys. We also examine the physical properties of the optically selected groups and compare them with the x-ray emitting subset. In Section 5 we conclude by comparing the USGC with similarly constructed catalogs based on distinct redshift surveys including the ESO Key Programme (Ramella et al. 1999) and the LCRS (Tucker et al. 2000).

2. The Data

We derive the group catalog from the official distributions of the UZC (http://cfa-www.harvard.edu/ falco/UZC/) and SSRS2 catalogs. We retrieve the SSRS2 from CDS using VizieR (Ochsenbein et al. 2000). In the UZC catalog (Falco et al. 1999) we use only the >98% complete region limited by $-2.5° \leq \delta_{1950} \leq 50°$ and $8^h \leq \alpha_{1950} \leq 17^h$ in the North Galactic Cap and by $20^h \leq \alpha_{1950} \leq 4^h$ in the South Galactic Cap. We discard the regions $-13° \leq b \leq 13°$ and $\alpha_{1950} \geq 3^h$ in the southern galactic region because of the greater galactic absorption there (Padmanabhan et al. 2001). We consider only galaxies with $cz < 15000$ km s^{-1}. There are 13333 galaxies in the subset of the UZC catalog we analyze.

The boundaries of the SSRS2 (da Costa et al. 1998) are $-40° \leq \delta \leq -2.5°$ and $b_{II} \leq 40°$ for SSRS2 South and $\delta \leq 0°$ and $b_{II} \geq 35°$ for SSRS2 North. Here, too, we consider only galaxies with $cz < 15000$ km s^{-1}. The UZC and SSRS2 catalogs have slightly different magnitude systems, m_{Zw} and m_{SSRS2} respectively. Detailed discussions comparing m_{Zw} and m_{SSRS2} are in Alonso et al. (1994) and, more recently, in Marzke et al. (1998). We use magnitudes as listed within the UZC and SSRS2 catalogs and apply the appropriate luminosity functions.

The SSRS2 and UZC overlap in the declination range $-3.8^\circ < \delta_{1950} \leq 0^\circ$ and $140^\circ < \alpha_{1950} < 240^\circ$. In this region the UZC contains 472 galaxies, about twice as many galaxies as SSRS2 (260 galaxies). Out of the 472 UZC galaxies in the Overlap Region (OR), 223 appear in both catalogs (we call this set of galaxies U_{both} ; and the remaining 249 galaxies UZC galaxies make up the sample U_{only}). We use the DSS to verify that the UZC objects omitted from the SSRS2 are galaxies. We note that 37 SSRS2 galaxies have no UZC counterpart. Of these 37 galaxies, 10 are very bright NGC galaxies also within UZC, but outside the half arcminute radius we search for UZC counterparts. These 10 galaxies are so bright and rare that they do not enter the magnitude comparison below. Extending our search to a 6 arcmin radius does not yield counterparts for the remaining 27 galaxies. These 27 galaxies have apparent magnitudes spread throughout the SSRS2 range; the sample of these galaxies is too small to draw any statistically interesting conclusions and they have little effect on the analysis below.

The issue of completeness to the magnitude limit is of obvious importance for the normalization of the luminosity function and potentially for the determination of large-scale structure parameters. Several authors have addressed the problem of the "quality" of m_{Zw} (Huchra 1976; Bothun & Cornell 1990; Takamiya et al. 1995; Grogin & Geller 1999; Gatzañaga & Dalton 2000) and of m_{SSRS2} (Alonso et al. 1993, 1994). Most of these authors use CCD photometry to calibrate either m_{Zw} or m_{SSRS2}. The task is difficult because the CCD photometric samples are limited and there are biases that can be introduced by the selection of the calibrating galaxies and by the choice of photometric techniques. It is perhaps not surprising that results are mostly discordant.

Given the lack of a "final word" on the two magnitude systems, it is worth investigating the difference between galaxy counts in the OR. For the 223 galaxies in the U_{both} sample, we can compare m_{SSRS2} to m_{Zw} directly; this sample is similar in size to those in previous

studies. Of course, extension of the conclusions throughout the catalogs may not be warranted.

The 223 U_{both} galaxies are brighter, on average, than the U_{only} galaxies: only 25 U_{both} galaxies are fainter than $m_{Zw} = 15.20$; 170 U_{only} galaxies are fainter than this limit. The distribution of m_{Zw} in the OR is very similar to the distribution of m_{SSRS2} in the same region. The only significant difference occurs at the magnitudes fainter than $m_{Zw} = 15.2$, more frequent among Zwicky magnitudes.

We suggest that m_{SSRS2} and m_{Zw} are not equivalent and that SSRS2 magnitudes are systematically brighter than UZC magnitudes, at least in the OR. A least squares fit to the relationship m_{Zw} vs. m_{SSRS2} for U_{both} galaxies yields $m_{Zw} = 0.78\ m_{SSRS2} + 3.16$. We use this relation to transform m_{SSRS2} into new magnitudes, $m_{SSRS2,new}$, that can be compared directly to m_{Zw} . The new magnitude limit is $m_{SSRS2,new} = 15.25$. This brighter limit is the true limit that should be used for m_{Zw} when comparing SSRS2 and UZC magnitudes.

Remarkably, the magnitude limit $m_{Zw} \leq 15.25$ leaves 277 UZC galaxies in the OR, very close count the 260 SSRS2 galaxies. Furthermore, a KS test shows that the distributions of m_{Zw} and $m_{SSRS2,new}$ have a probability greater than 98% of having been drawn from the same parent population.

The results we obtain in the OR may be valid everywhere else in the two surveys. In fact, the distributions of m_{SSRS2} and m_{Zw} within the OR do not differ significantly from the magnitude distributions of the entire SSRS2 and UZC, respectively. If we set $m_{Zw} = 15.25$ as the new magnitude limit for the whole UZC, there are 4842 galaxies in the UZC; there are 4824 SSRS2 galaxies. The solid angle of both regions of the sky is about 1.6 sr. Thus the angular number densities of galaxies in the two surveys **coincide**. With the original fainter UZC limiting magnitude, the angular densities of the UZC and SSRS2 are 5200 galaxies sr^{-1} and 3090 galaxies sr^{-1} respectively.

Our analysis of the OR indicates that the UZC is a deeper survey than the SSRS2 and that a linear transformation is needed to make m_{Zw} and m_{SSRS2} comparable. We note that Alonso et al. (1994) also analyze galaxies in common between Zwicky's CGCG (Zwicky et al. 1961—1968) and SSRS2. However, these authors focus on the U_{both} sample and ignore the presence of the large sample of U_{only} galaxies. Without taking the U_{only} galaxies into account, and ignoring possible scale errors, they conclude that the average difference between m_{SSRS2} and m_{Zw} is of the order of 0.1 mag and that it can be ignored in the analyses of UZC and SSRS2. Because we cannot verify that the results of our analysis of the OR can be extended robustly over the entire UZC or SSRS2, we do not attempt to unify selection functions but rather use the appropriate selection function in each survey. Relative to their selection functions, groups in the two surveys have similar properties. Indeed, we will show below that the number of groups *relative to the underlying galaxy distribution* and their main physical parameters are not significantly different within the UZC and SSRS2 surveys. If the transformation between m_{Zw} and m_{SSRS2} is correct throughout the catalog, some "absolute" properties of groups will differ somewhat in the approach we take here. For example, the average galaxy density within individual groups will be slightly different in the UZC and SSRS2. We note, however, that other uncertainties than magnitude scale errors may dominate the identification of physically bound systems of galaxies and the determination of their masses. We do not know either the "true" distances of galaxies independent of their velocities and thus we do not have an estimate of the "true" spatial galaxy density. It is beyond the scope of this paper to determine the ultimate underlying reason for the discrepancy between the two catalogs in the overlap region. It is also difficult to evaluate the propagation of these differences. Progress will be made with large digital sky surveys, like 2MASS and the on-going SDSS, which will provide homogeneous and uniform CCD photometry and galaxy catalogs over large regions of the sky. Here we discuss groups that have been used in a number of different analyses, we take the magnitudes in

the two catalogs at face value and make no transformation. We use the UZC catalog in the overlap region. The difference in selection of galaxies within UZC and SSRS2 in the overlap region confuses the definition of groups at the border between the two surveys; to avoid this problem we introduce a half degree gap between the two surveys. In conclusion, the SSRS2 catalog we analyze consists of 4824 galaxies.

Figure 1a shows the distribution on the sky of the UZC and SSRS2 galaxies included in our analysis. We also plot (large dots) the position of the Abell/ACO clusters within the volume of the survey (Andernach 1991). We download Andernach's updated electronic table from CDS using VizieR (Ochsenbein et al. 2000). Several Abell/ACO clusters lie just outside the border of the SSRS2 survey. We discuss the consequences of omission of these dense regions below.

3. The Algorithm

Friends-of-friends algorithms (FOFA) are now a standard approach to identifying systems of galaxies in a redshift survey. We apply the FOFA originally proposed by Huchra & Geller (1982) as implemented by Ramella et al. (1997). The "linking" parameters D_L and V_L characterize the FOFA search: for each galaxy in the catalog, the FOFA identifies all other galaxies with a projected separation

$$D_{12} \leq (V_1 + V_2)\sin(\theta/2)/H_o \leq D_L(V_1, V_2, m_1, m_2) \tag{1}$$

and a line-of-sight velocity difference

$$V_{12} \leq |V_1 - V_2| \leq V_L(V_1, V_2, m_1, m_2). \tag{2}$$

Here, V_1 and V_2 are the velocities of the two galaxies in the pair, m_1 and m_2 are their magnitudes, θ is their angular separation, and H_o is the Hubble constant. We assume a

Hubble constant $H_\circ = 100h$ km s^{-1} Mpc^{-1} with $h = 1$ when an explicit value is required. All pairs linked by a common galaxy form a “group”.

We estimate the limiting density contrast as

$$\frac{\delta\rho}{\rho} = \frac{3}{4\pi D_o^3}\left[\int_{-\infty}^{M_{lim}} \Phi(M)dM\right]^{-1} - 1. \tag{3}$$

Here $\Phi(M)$ is the luminosity function for the sample, M_{lim} is the faintest absolute magnitude at which galaxies in a sample with magnitude limit m_{lim} are visible at a fiducial velocity $V_F = 1000$ km s^{-1} , and D_o is the linking parameter D_L at V_F (Ramella et al. 1989). We scale scale D_L and V_L to keep the number density enhancement, $\delta\rho/\rho$, constant. The scaling is

$$D_L = D_o R \tag{4}$$

and

$$V_L = V_o R, \tag{5}$$

where

$$R = \left[\int_{-\infty}^{M_{lim}} \Phi(M)dM / \int_{-\infty}^{M_{12}} \Phi(M)dM\right]^{1/3} \tag{6}$$

and

$$M_{12} = m_{lim} - 25 - 5\log((V_1 + V_2)/2H_o) \tag{7}$$

The ratio D_L/V_L is constant.

We define an association of three or more galaxies as a “group”. We consider only groups with mean velocities in the range 500 km s^{-1} $< V <$ 12000 km s^{-1} . This value allows a straightforward comparison with the majority of published results on subsamples of CfA groups. For the UZC, the Schechter (1976) form of the galaxy luminosity function (LF) has $M_\star = -19.1$, $\alpha = -1.1$, and $\phi_\star = 0.04\ h^3$ Mpc^{-3}. We obtain these values of the parameters by convolving an 0.3 magnitude Gaussian uncertainty with the LF determined by Marzke et al. (1994) for a very similar sample. There is no significant difference between the *old* Ramella et al. (1997) groups the *new* UZC groups where these two samples overlap. Any differences result from the use of the more accurate UZC coordinates and redshifts. For the SSRS2, the luminosity function parameters are $M_\star = -19.73$, $\alpha = -1.2$, and $\phi_\star = 0.013\ h^3$ Mpc^{-3}. We obtain these parameters by convolving the 0.3 magnitude uncertainty with the LF determined by Marzke et al. (1994).

We set D_0 to correspond to a density contrast threshold $\delta\rho/\rho = 80$ within both the UZC and SSRS2. Because the luminosity functions differ slightly for the two catalogs, the linking parameters differ somewhat at the reference velocity, V_F. For both surveys, the fiducial linking parameters are approximately $D_0 = 0.25h^{-1}$ Mpc and $V_0 = 350$ km s^{-1} at $V_F = 1000$ km s^{-1} . Ramella et al. (1997) discuss how group catalogs vary with $\delta\rho/\rho$ and V_0 . They conclude that group properties are statistically stable for $\delta\rho/\rho$ in the range 80 to 160. The choice $\delta\rho/\rho = 80$ guarantees inclusion of the loosest systems and minimzes the chance splitting of the richest systems. The choice of V_0 is more critical. Ramella et al. (1997) adopt the value we use here based on the following considerations: a) for this choice of V_0, the velocity dispersions of the richest systems identified with FOFA match the dispersions obtained from much larger samples (e.g. Zabludoff et al. (1993)), b) observations show that groups obtained with $V_0 = 350$ km s^{-1} are stable against inclusion of fainter members (Ramella et al. 1995, 1996), c) analysis of the performances of FOFA on cosmological n-body simulations show that $V_0 = 150$ km s^{-1} biases velocity dispersions

toward low values and that $V_0 = 550$ km s^{-1} produces highly inaccurate groups (Frederic 1995a).

In a group catalog selected from a redshift survey with a FOFA, some fraction of the groups are accidental superpositions. We have two measures of the fraction of true physical systems in the USGC catalog. Ramella et al. (1997) use geometric simulations of the large-scale structure in the Northern UZC region to demonstrate that at least 80% of the groups with five or more members are probably physical systems. Diaferio et al. (1999) find similar results in their analysis of mock CfA surveys extracted from n-body simulations. Mahdavi et al. (2000) cross-correlate a large fraction of these richer groups with the ROSAT All-Sky Survey (RASS). A total of 61 groups, the "RASSCALS", in the Mahdavi et al. (2000) sample have associated extended x-ray emi+ssion. The presence of hot x-ray emitting gas bound in the group potential well is a confirmation of the physical reality of the system. Mahdavi et al. (2000) use the groups detected in the x-ray to show that a minimum fraction of 40% of the groups in the subsample are similar x-ray emitting systems undetectable with the RASS; thus they set a lower limit of 40% on the fraction of real physical systems in the group catalog. We conclude that 40-80% of the groups with five or more members are real and it is thus reasonable to use their properties to derive physical constraints on the nature of groups of galaxies. Of course, the statistical reliability is substantially less for the 3 and 4 member groups. We include these systems as a finding list.

4. The Group Catalog

The USGC catalog contains 1168 groups, with the UZC and SSRS2 regions containing 864 and 304 groups with a total of 5242 and 1604 member galaxies, respectively. For each group, Table 1 lists the group ID number, the number of members within the survey, N_{mem},

the mean coordinates (J2000), the mean heliocentric radial velocity, an unbiased estimate of the velocity dispersion (Ledermann 1984) corrected for measurement errors and reduced to the source redshift (Danese et al. 1980), the virial radius, the virial mass, the logarithm of the mass-to-light ratio, the logarithm of the observed luminosity and the logarithm of the total luminosity corrected for the unseen luminosity to $M_{Z}w$ = -13.0 assuming a simple extrapolation of the relevant luminosity function. We note that Table 1 lists the virial radius $R_{vir} = 2R_h N_{mem}/(N_{mem} - 1)$ (see e.g. Jackson 1975; Rood & Dickel 1978); Ramella et al. (1997) actually list R_h, the harmonic radius. Only the beginning of Table 1 is included here; the entire table is available electronically.

Table 2 is a sample of the list of group members; again the full list is available electronically. For each member we list the ID number of the parent group, the galaxy coordinates (J2000) and magnitude as in the UZC or SSRS2, the heliocentric velocity, and the velocity error.

We cross-identify groups in the USGC catalog with the $N_{mem} \geq 5$ member groups in Ramella et al. (1997) and with the x-ray detected RASSCALS. Small changes in the original galaxy catalogs and improved luminosity functions have small statistical effects on the membership and/or physical parameters of the groups. Table 3 lists the cross-identifications with Ramella et al. (1997); Table 4 contains cross-identifications with the RASSCALS. All of the RASSCALS detected in the x-ray are also in the USGC.

5. Properties of Groups

Because of its size, the USGC catalog offers an opportunity to study a broad range of physical properties of groups as a class of systems. We consider the velocity dispersion, mass, and mass-to-light ratio here. Girardi et al. (2000) evaluate the group correlation

function. Mahdavi et al. (2000) consider the x-ray properties of groups in this sample. Pisani et al. (2002, in preparation) evaluate the multiplicity function.

Although the combined catalog covers 4.69 steradians, the sampling of the distribution of rich clusters of galaxies is limited to a few systems. For the SSRS2 which covers 1.56 steradians, the problem of the small number of systems with large velocity dispersion is most serious. In their study of the pairwise velocity dispersion for the CfA (a subset of the UZC) and SSRS2 South surveys, Marzke et al. (1995) show that the dominant source of variance in σ_{12} from one subsample to another is shot noise contributed by dense virialized systems with large velocity dispersion. We thus expect to uncover similar limitations in our examination of the properties of groups. In Section 5.1 we use the entire USGC catalog with three or more members to show that selection of groups is homogeneous across the two catalogs. In section 5.2 we specialize to the higher confidence groups with more than five members to discuss the typical physical properties of the systems. In section 6 we show that the groups identified as extended x-ray sources have similar properties in both the UZC and in the SSRS2. We conclude that, in spite of the differences between the underlying galaxy catalogs, the group catalog is reasonably homogeneous across the two surveys and provides a useful foundation for the study of properties of these systems at low redshift.

5.1. The Number of Group Members

Table 5 lists the number of groups, members, non-members ($cz \leq 12000$ km s^{-1}) and galaxies within the USGC. We also list these quantities separately for the two surveys. From Table 5, we conclude that the UZC projected angular density of groups, $\Sigma_{UZC} = 276$ sr^{-1}, is 1.4 times larger than the SSRS2 projected angular density, $\Sigma_{SSRS2} = 195$ sr^{-1}. The Poisson uncertainty on the angular densities is of the order of 10 groups sr^{-1}; thus the difference between Σ_{UZC} and Σ_{SSRS2} is significant. In principle, the group-group correlation

function increases the uncertainty relative to the Poisson estimate. However, the amplitude of the angular group-group correlation function, $s_0 = 8h^{-1}$ Mpc (Girardi et al. 2000), is small compared with the size of the two surveys. Therefore we expect that the effect of the the group-group correlation function on the uncertainty is negligible.

Our discussion of the UZC and SSRSS2 magnitude scales in Section 2, indicates that the UZC is deeper than the SSRS2 and that a transformation between the two magnitude systems may be required. In the spirit of that discussion, we ask what happens to the relative surface number densities of groups if we simply drop UZC galaxies fainter than $m_{Zw} = 15.25$ and construct a catalog with $N_{mem} \geq 3$. The group angular densities come into much better agreement, with 160 and 190 groups sr^{-1} within UZC and SSRS2 respectively Shifting the limiting magnitude from $m_{Zw} = 15.25$ to $m_{Zw} = 15.30$ yields exactly the same angular densities. Although this apparently improved agreement is enticing, we have no clear justification for extrapoolating the results from the overlap region to the entire survey. The definition of survey boundaries may introduce bias in the survey. Several ACO clusters are just outside the boundary of SSRS2 (see Figure 1a). Because the correlation length of the richest systems is much larger than for groups (e.g. Bahcall & West 1992; Borgani et al. 1999), we consider the projected angular density of poor systems as a standard for comparing the two catalogs (without any correction for possible differences in the magnitude systems) . To estimate a "richness", we set all groups at the same fiducial velocity $V_F = 1000$ km s^{-1}. We then use the relevant luminosity function normalized to the observed N_{mem} to compute the expected number of members with $M_{Zw} \leq -14.5$, the absolute magnitude corresponding to $m_{lim} = 15.5$ at V_F. We thus obtain a corrected number of members for each group, N_{mem,V_F}. The upper quartile of N_{mem,V_F} is $N_{UQ} = 110$ members. The projected angular densities of groups poorer than N_{UQ} are $\Sigma_{poor,UZC} = 188$ sr^{-1} and $\Sigma_{poor,SSRS2} = 173$ sr^{-1}, in reasonable agreement even under the conservative hypothesis of Poisson uncertainties. The result is insensitive to the exact choice of N_{UQ}. This result

suggests that, as in the analysis of Marzke et al. (1995), the richest systems account for the different group abundances within the UZC and SSRS2.

To examine the homogeneity of the entire groups catalog further, we examine the ratio between the number of groups, N_{gr}, and the number of galaxies, N_{gal}. In the redshift range 0 km s^{-1} $< cz <$ 12000 km s^{-1}, there are 4484 galaxies within the SSRS2 and 12186 galaxies within the UZC yielding N_{gr}/N_{gal} = 0.068 and 0.071 respectively, with a Poisson uncertainty of order ± 0.004. Figure 2 shows that these ratios are approximately constant for the two surveys over a wide range of redshifts. At radial velocities $\gtrsim$ 10000 km s^{-1}, groups become relatively less abundant within the SSRS2, but the significance of the difference is low. The $\pm 1\sigma$ Poisson error bars in Figure 2 are underestimates because groups and galaxies are clustered. Figure 2 supports the hypothesis that Σ_{UZC} and Σ_{SSRS2} differ only because of "fair sampling" issues: relative to the number of galaxies in each survey, the abundance of groups is essentially the same.

The number of members relative to the galaxy population in the two surveys gives another measure of the similarity of the group catalogs. In principle, even if our test of the number of groups is satisfactory, the distribution of "richness" could differ in the two surveys.

To explore this issue, we consider the fraction of galaxies in groups. There is a total of 5242 member galaxies in the UZC groups, corresponding to a fraction $f_{UZC} = \Sigma_i N^i_{mem}/N_{gal} = 0.430 \pm 0.005$ of the total number of galaxies within 0 km s $^{-1}$ $< cz <$ 12000 km s^{-1}. In the SSRS2, $\Sigma_i N^i_{mem} = 1604$ and $f_{SSRS2} = 0.358 \pm 0.009$. Taken at face value, these fractions imply a difference between the SSRS2 and the UZC. From previous analyses of these catalogs we suspect that the source of the difference here is shot noise in the abundances of the richest systems in the two underlying redshift surveys. To investigate this possibility, Figure 3 shows the fraction of galaxies in groups, $f(cz)$,

in redshift bins (we count all members of a group within the redshift bin containing the group mean velocity): from 2000 km s^{-1} to 12000 km s^{-1} $f_{UZC}(cz)$ (thick solid line) is increasingly larger than $f_{SSRS2}(cz)$ (thin solid line). Because the width of the redshift bins is relatively close to the correlation length of groups, we do not use Poisson error estimates. We estimate the 1-σ error-bars in Figure 3 by running a bootstrap procedure 10000 times in each cz bin. For each bootstrapped sample we compute the total number of members and compute $f^i(cz), i = 1, .., 10000$. Error-bars in Figure 3 are 1-σ of the bootstrapped distribution of $f(cz)$. To see whether the difference in $f(cz)$ for all groups is attributable to the richest systems, Figure 3 also shows $f(cz)$ for the poor groups with $N^i_{mem,V_F} < 110$. Without the rich systems, $f_{UZC}(cz)$, filled circles, and $f_{SSRS2}(cz)$, empty circles, are in reasonable agreement.

We conclude that groups within the SSRS2 and UZC are very similar for both their abundance and membership *relative to the galaxy distribution*. If we exclude the richest systems, the fraction of galaxies identified as group members is the same at any redshift in both surveys. This result indicates that observational biases in the UZC relative to the SSRS2 do influence the identification of groups significantly.

5.2. The physical properties of groups

To examine some of the physical properties of groups, we restrict the analysis to higher confidence systems with at least five observed members. There are 313 such groups in the UZC and 98 in the SSRS2. Table 6 lists the median and 90% confidence levels of the velocity dispersion, σ_{cz}, the virial radius, R_{vir}, the mass, M_{vir}, and the mass-to-light ratio, M/L. We compute the luminosity from the original Zwicky magnitudes for the UZC; we use the SSRS2 catalog magnitudes for SSRS2 groups. In combining the catalogs we ignore possible differences between the two magnitude systems. We list the median properties for

the combined group sample and for the individual UZC and SSRS2 samples.

Table 6 shows that, in spite of differences in the construction of the UZC and SSRS2, the median properties of groups are the same. We use KS tests to compare the distributions of these properties of groups within the UZC and SSRS2. We find that, nothwhistanding the almost coincident medians, the distributions of σ_{cz} and M within UZC and SSRS2 are unlikely to be drawn from the same parent distribution (at the >99% confidence level).

To assess the source of the results for the σ_{cz} and M distributions, Figure 4 shows the integral distributions of σ_{cz} for systems within the UZC (thick histogram) and the SSRS2 (thin histogram). Again we see the issue we have uncovered before: groups with high velocity dispersion explain the difference between the two distributions.

To explore this issue further we divide the group catalog into rich and poor subsamples. Again, we divide the sample based on the third quartile of the corrected richness appropriate for groups with five or more members, $N_{UQ,5} = 200$ (see section 5.1), we drop eight groups with $cz \leq 1000$ km s^{-1} (these systems are within the Local Supercluster). Figure 4 compares the integrated distributions of σ_{cz} for the poor subsamples of groups. A KS test shows that these subsamples are unlikely to be drawn from different distributions (P(KS) = 39%). The situation is similar for the distribution of M. Table 6 explores the variation in median physical parameters of the four poor/rich group subsamples (excepting the small subsample of five SSRS2 rich groups). The median quantities for the poor subsamples are in excellent agreement with the full SSRS2 sample but differ from the total UZC. As expected, the rich UZC groups have a significantly larger median σ_{cz} and M. In contrast the median M/L is remarkably consistent for all subsamples.

We conclude that both the UZC and SSRS2 provide fair samples of poor systems. These systems have similar statistical properties in the two catalogs.

6. X-ray groups

A subsample of 61 groups in the USGC are extended x-ray sources detected in the RASS (Mahdavi et al. 2000). These groups are an important subset because the x-ray emission from gas presumably held in the potential well of the group guarantees that these groups are real physical systems. It is therefore interesting to compare their physical parameters to those for all groups in the catalog. Of the 61 groups, 16 are within SSRS2 and 45 within UZC. Therefore about $\sim 15\%$ of the groups in both samples are detected in the RASS. Among the x-ray emitting groups, 41 are poor according to the definition in section 5.2. Table 6 lists the physical parameters of the entire x-ray-emitting subsample. It is not surprising that median σ_{cz} is intermediate between the rich and poor subsamples. The x-ray detected groups are systematically more massive than the typical system in the poor groups catalog. One concern is that this difference is simply a selection effect; the x-ray identification might pick out more distant, richer groups. However, a KS test demonstrates that the velocity distribution of the poor groups detected in the x-ray poor groups is consistent with the entire poor USGC sample. This consistency is reassuring; it indicates that the sample of poor groups with five or more members provides a foundation for the assessment of the physical properties of these systems and their member galaxies.

7. Conclusion

The UZC and SSRS2 redshift surveys provide the basis for the USGC catalog which covers 4.69 steradians to 12000 km s^{-1} . The FOFA identifies a homogeneous set of 411 systems with more than five observed members. For completeness and for verification of the uniformity of the catalog we include all 1168 groups with 3 or more members.

For poor systems in the first three quartiles of the "richness" distribution, the surface

number density of groups, the fraction of galaxies in groups, and the properties of groups are essentially the same for both the UZC and for the SSRS2 . In the upper quartile, the catalogs differ: only the UZC contains a substantial number of these systems. As in Marzke et al. (1995) we attribute this difference to shot noise in the sampling of the most massive systems in the smaller SSRS2 survey. Both the UZC and the SSRS2 appear to be large enough to yield a fair sample of poor systems. The UZC and SSRS2 catalogs overlap in a region which covers ~ 0.11 sterad. In this region, the UZC contains almost twice as many galaxies than SSRS2. We obtain a linear transformation between m_{Zw} and m_{SSRS2} for galaxies that have both magnitudes. The new $m_{SSRS2,new}$ is directly comparable to m_{Zw} , and its faintest value is $m_{SSRS2,new} = 15.25$. Cutting the UZC at this shallower limit brings the UZC and SSRS2 catalogs into remarkable agreement in the overlap region.

If we extend the limit $m_{Zw} = 15.25$ to the whole UZC, the global angular number densities of galaxies in the UZC and SSRS2 become comparable. The angular number density of groups in the shallower UZC catalog is essentially the same as for the SSRS2. However, the main physical properties of groups do not change with re-identification within the shallower UZC or within SSRS2 using $m_{SSRS2,new}$ instead of m_{SSRS2} . In these modified catalogs it remains true that the UZC has a larger number of rich, high velocity systems than SSRS2 and that the σ_{cz} distributions of "poor" groups in the two surveys are likely to be drawn from the same parent distribution.

Extended x-ray emission associated with a subset of the USGC with more than five observed members provided reassurance that a large fraction of the systems we identify are true physical associations. Statistical comparison of the x-ray and optical selection suggests that at least 40% of the groups we identify have x-ray properties similar to the RASS sample. Geometric analyses of a portion of the UZC suggest that $\sim 80\%$ of the groups are true physical systems. Comparison with n-body simulations confirm this upper limit.

Ramella et al. (1999) used the same procedure we apply here to derive a group catalog from a deeper redshift survey of an independent region, the ESO Slice Project (ESP). The ESP group catalog includes a remarkably similar fraction of the galaxies in the redshift survey. Furthermore, the median velocity dispersion of groups with five or more members is 272 km s^{-1} with an interquartile range of (178, 379) km s^{-1} essentially the same as the comparable USGC sample with a median velocity dispersion of 264 km s^{-1} and an interquartile range of (150, 407) km s^{-1} . Other physical properties of the groups in this deeper catalog are also similar to those for the USGC. Tucker et al. (2000) compare the properties of groups derived from the Las Campanas Redshift Survey (Lin et al. 1996, LCRS;) with a broad range of catalogs including the subset of the USGC discussed by Ramella et al. (1997). Tucker et al. (2000) conclude that the properties of their groups at median redshift $z \sim 0.1$ are similar to the systems in the nearby samples. Groups have traditionally provided a basis for estimating the mean mass density of the universe. Now there are better methods of approaching this issue (e.g. Riess et al. 1998; Perlmutter, S., et al. 1999; Balbi et al. 2000; de Bernardis et al. 2000; Melchiorri et al. 2000). However, the existence of algorithms which produce uniform catalogs of systems, many of which are true physical associations, is a basis for exploration of groups as environments for galaxy evolution and for investigation of groups as tracers of large-scale structure in the universe. The USGC provides an extensive low redshift baseline for these studies.

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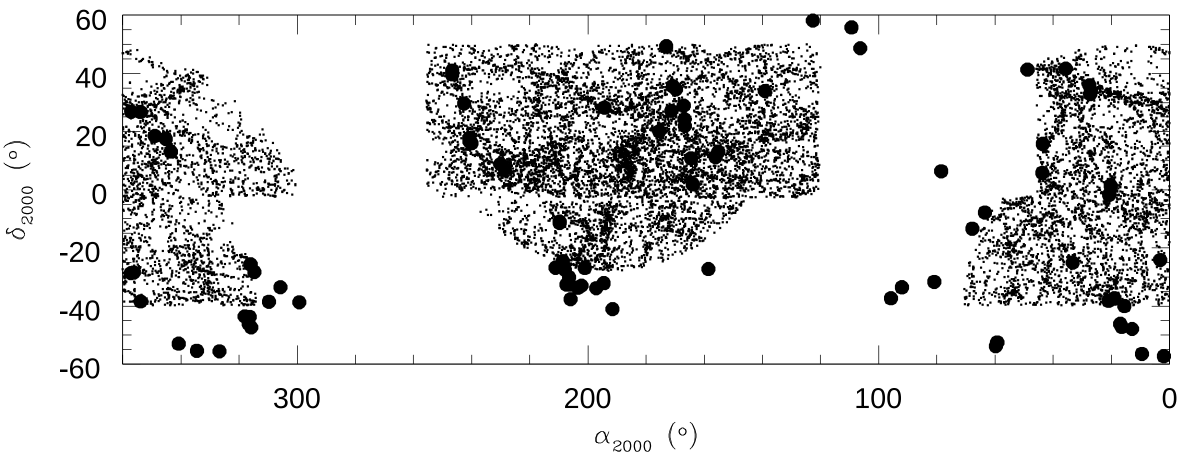

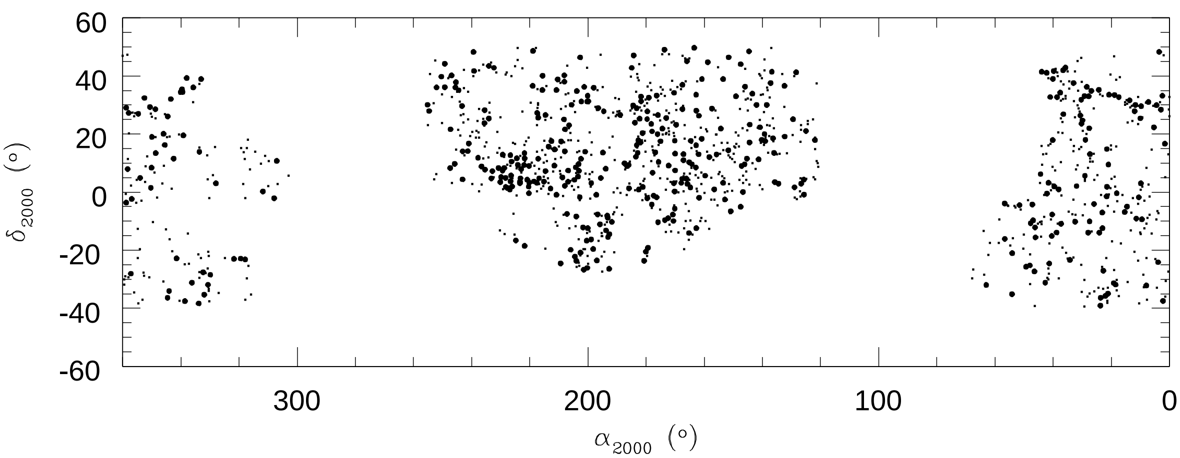

Fig. 1.— (a) Right ascension and declination of UZC and SSRS2 galaxies. Large dots are Abell/ACO clusters with measured redshift cz $\leq$ 12000 km s^{-1} . (b) Right ascension and declination of the USGC groups. Smaller points are triplets and quadruplets; larger points are groups with at least five members in the redshift catalog.

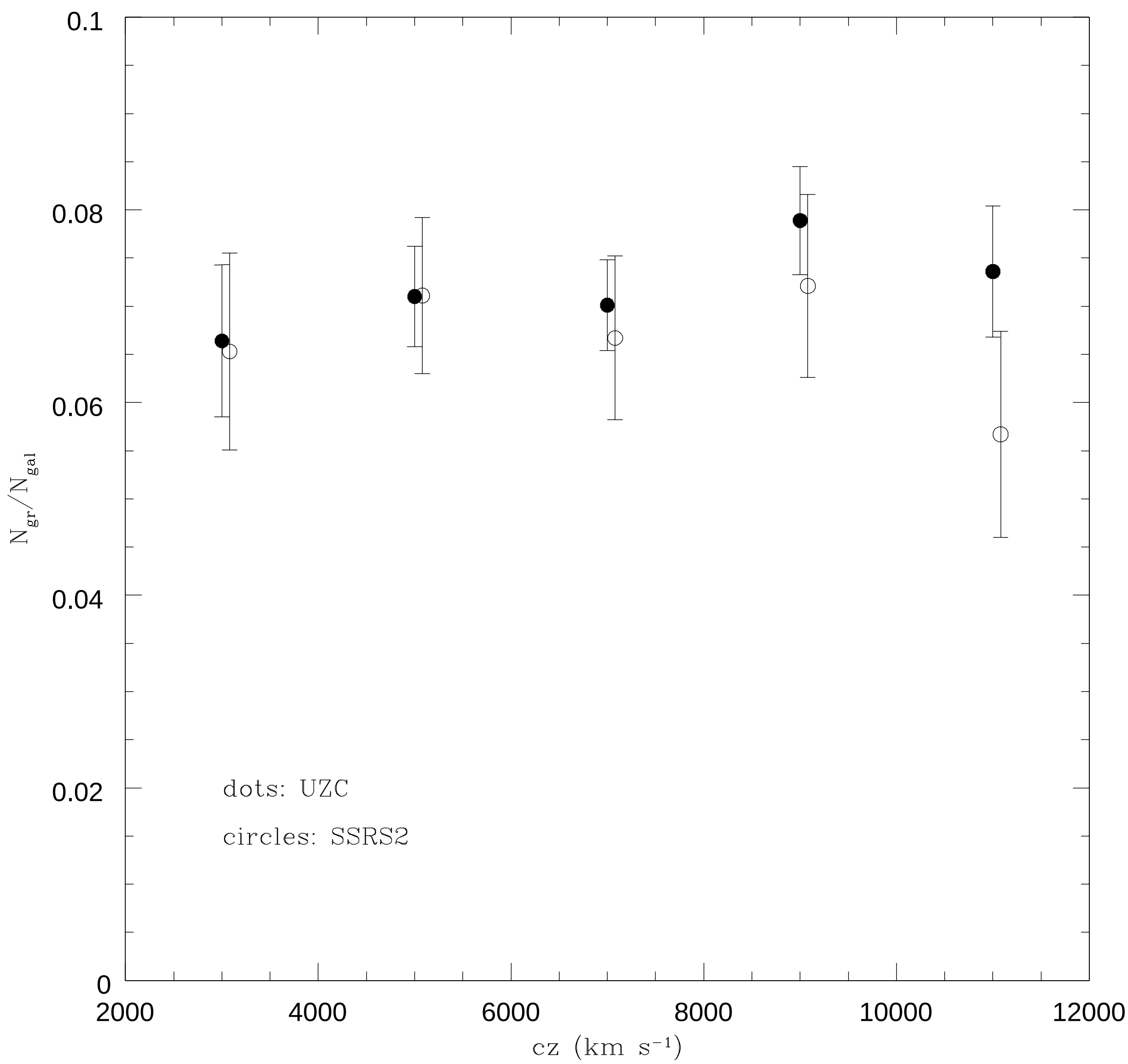

Fig. 2.— Ratio N_{gr}/N_{gal} computed in redshift bins. Error bars indicate $\pm 1\sigma$, Poisson errors. Filled symbols are for UZC, empty symbols for SSRS2.

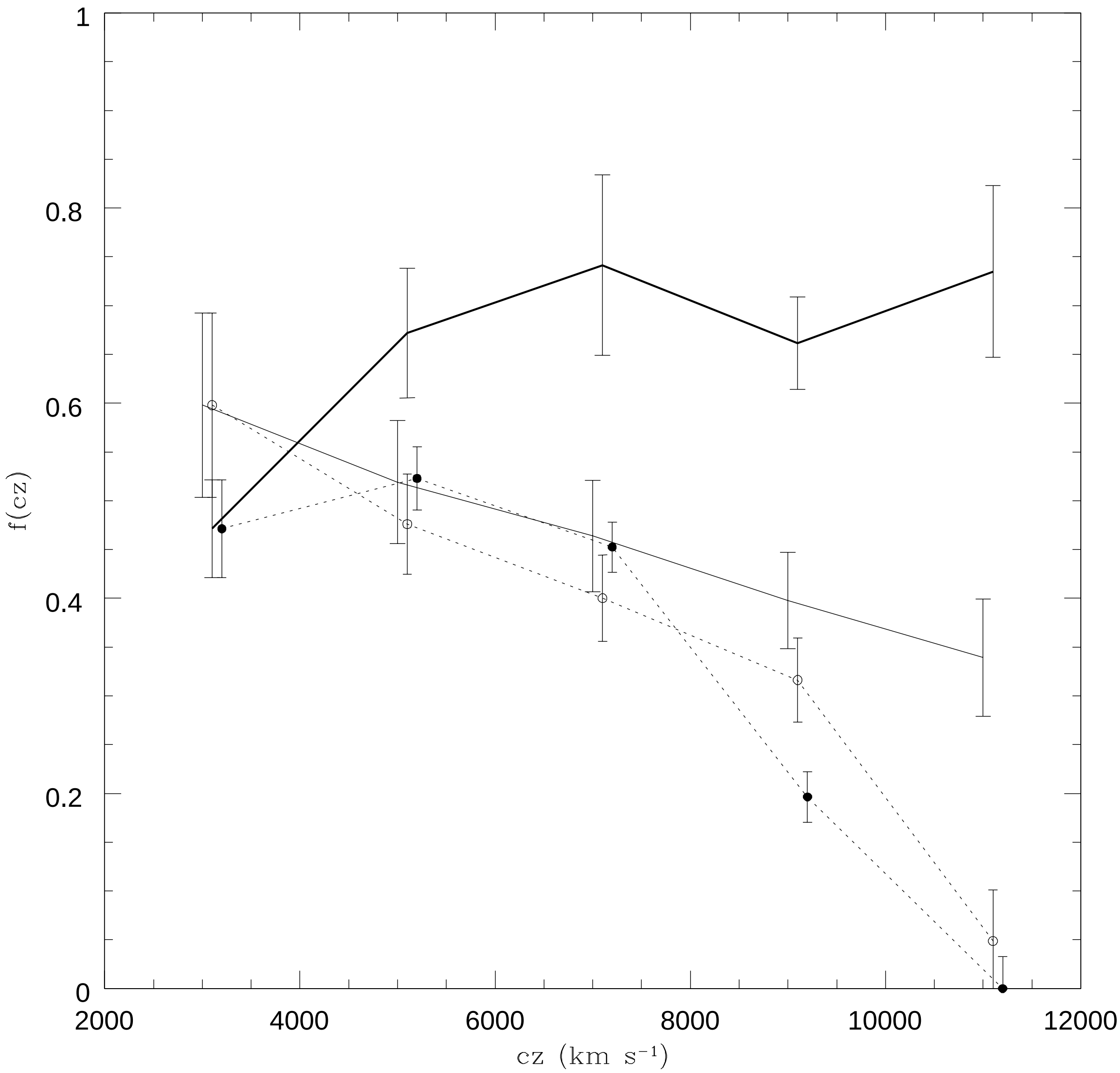

Fig. 3.— Fraction of galaxies in groups, f(cz), within UZC (thick solid line) and SSRS2 (thin solid line). Error bars correspond to $\pm 1\sigma$ estimated using 10000 bootstrap samples. Dotted lines represent f(cz) computed for "poor" groups within UZC (filled symbols) and SSRS2 (empty symbols) - error bars have been omitted for clarity.

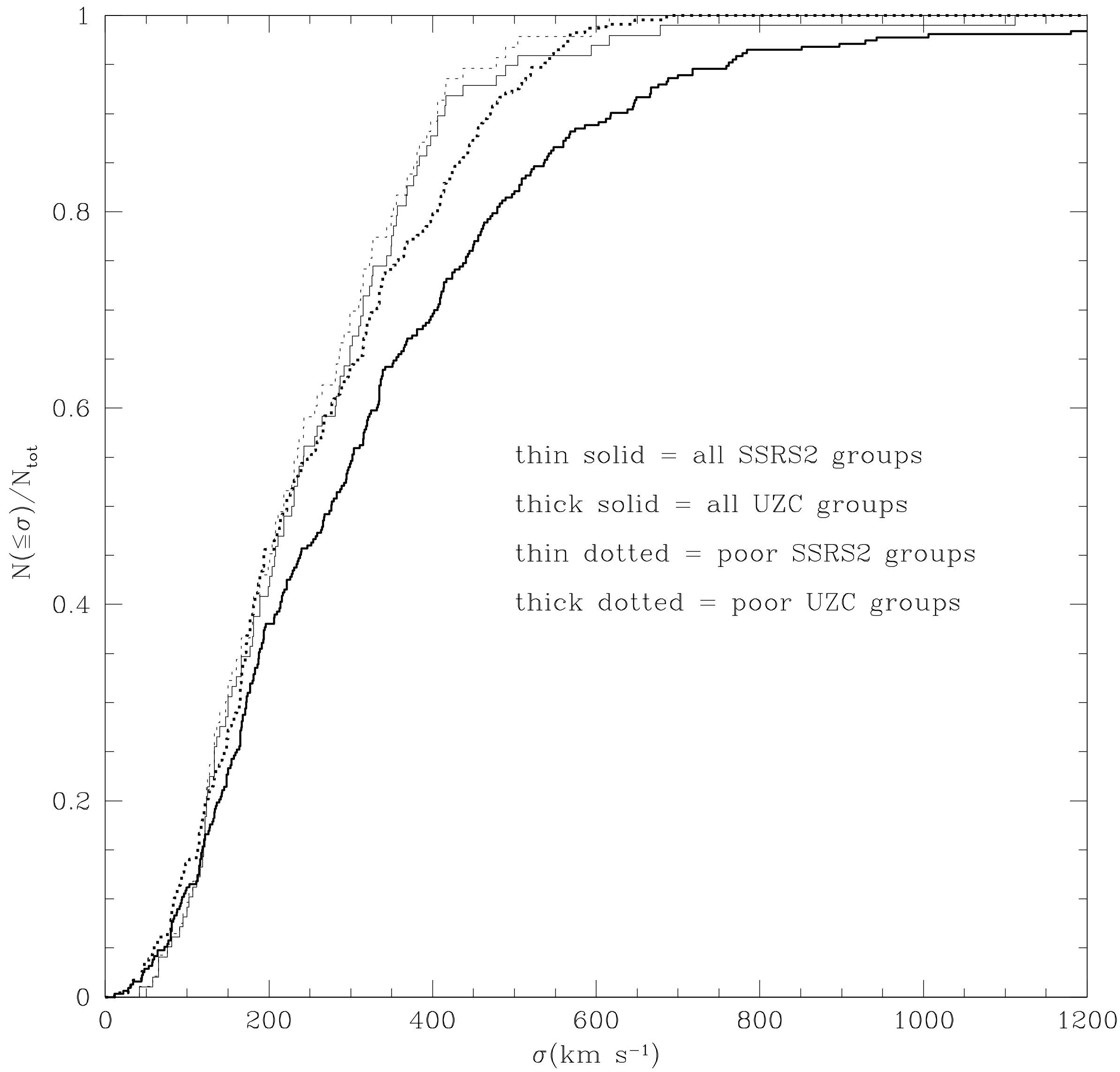

Fig. 4.— Normalized integral distributions of σ_{cz} for systems within the UZC (thick histogram) and SSRS2 (thin histogram). Solid lines are for all groups, dotted lines for "poor" groups.

Table 1. UZC-SSRS2 Group Catalog.[a]

ID	N_{mem}	α_{2000}	δ_{2000}	$c\bar{z}$	σ_{cz}	R_{vir}	log(M)	log(M/L)
		$hh\ mm\ ss$	$^{\circ}\ '\ ''$	kms^{-1}	kms^{-1}	$Mpc\ h^{-1}$		
U001	3	00 00 05.6	26 11 25	7450	482	0.61	13.99	3.15
U002	4	00 00 07.7	32 45 58	10190	202	0.58	13.22	1.73
U003	3	00 00 43.0	28 23 45	8560	391	0.25	13.42	2.31
U004	3	00 01 41.8	13 03 54	5378	142	0.50	12.85	2.23
U005	4	00 05 38.3	05 09 32	5465	265	0.58	13.45	3.02
U006	5	00 06 07.7	16 40 50	972	136	1.07	13.14	3.60
U007	3	00 08 05.7	47 07 42	5173	139	0.58	12.89	2.44

[a]The complete version of this table is in the electronic edition of the Journal. The printed edition contains only a sample.

Table 2. USGC Member Galaxies.[a]

ID	N_{mem}	α_{2000} $(hh\ mm\ ss)$	δ_{2000} $(^{\circ}\ '\ '')$	m	cz (kms^{-1})	ϵ_{cz} (kms^{-1})
U001	3	00 00 31.7	+26 18 19	14.7	7754	52
U001	3	00 00 31.4	+26 19 30	14.7	7637	14
U001	3	23 59 13.7	+25 56 26	15.5	6959	37
U002	4	00 00 16.2	+32 47 33	15.1	10332	34
U002	4	00 00 14.8	+32 49 55	15.1	9956	69
U002	4	00 00 09.2	+32 44 18	14.9	10372	19
U002	4	23 59 50.6	+32 42 08	15.3	10100	52

[a]The complete version of this table is in the electronic edition of the Journal. The printed edition contains only a sample.

Note. — 'U' members are UZC galaxies, 'S' members are SSRS2 galaxies. Magnitude m is m_{Zw} for UZC galaxies and m_{SSRS2} for SSRS2 galaxies

Table 3. Crossreferences for RPG97 Groups [a]

RPG97	UZCGG
RPG002	U185
RPG004	U189
RPG007	U193
RPG008	U192
RPG015	U200
RPG016	U203

[a]The complete version of this table is in the electronic edition of the Journal. The printed edition contains only a sample.

Note. — Only RPG97 groups with $N_{mem} \geq 5$.

Table 4. Crossreferences for RASSCALS [a]

RASSCALS	USGC
NRGb004	U189
NRGb032	U223
NRGb045	U238
NRGb078	U288
NRGb128	U381
NRGb151	U412

[a]The complete version of this table is in the electronic edition of the Journal. The printed edition contains only a sample.

Note. — Only Madhavi et al. 2000 groups with extended x-ray emission

Table 5. Galaxy Counts.

Survey	Ω ($sterad$)	N_{gr}	N_{mem}	$N_{non-mem}$[a]	N_{gal}
U+S	4.69	1168	6846	9882	16728
UZC	3.13	864	5242	7020	12262
SSRS2	1.56	304	1604	2862	4466

[a] $cz \leq 12000$ km s^{-1}

Table 6. Properties of Groups with $N_{mem} \geq 5$.

Survey	N	σ_{cz} $(km s^{-1})$	R_{vir} $(Mpc\ h^{-1})$	$log(M/M_{\odot})$	$log((M/L)/(M_{\odot}/L_{\odot}))$
USGC	411	264 (229,292)	1.06 (0.98,1.14)	13.67 (13.59,13.76)	2.63 (2.58,2.68)
UZC	313	283 (247,315)	1.09 (1.01,1.17)	13.73 (13.64,13.84)	2.63 (2.57,2.67)
SSRS2	98	229 (199,259)	0.99 (0.89,1.13)	13.59 (13.39,13.69)	2.67 (2.56,2.76)
RASSCALS	61	409 (352,437)	1.10 (0.94,1.28)	14.02 (13.91,14.17)	2.64 (2.61,2.68)
UZC Poor	228	222 (194,254)	0.93 (0.88,1.01)	13.49 (13.42,13.62)	2.62 (2.56,2.69)
SSRS2 Poor	93	218 (189,242)	0.95 (0.88,1.11)	13.56 (13.37,13.65)	2.67 (2.56,2.76)
UZC Rich	77	506 (411,603)	1.84 (1.73,1.98)	14.43 (14.31,14.57)	2.63 (2.53,2.67)